Termite Survival on Various Types of Mulch

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Abstract: Laboratory tests were conducted to identify termite-resistant mulches which could be used for landscaping in termite infested areas. Termite survival was assessed using the eastern subterranean termite, *Reticulitermes flavipes*, in no-choice laboratory feeding tests on 15 mulch and ground cover materials over a 16-week period. Termites starved and mortality reached 100% by the 11-12th week on decorative stone, rubber mulch, cocoa shell mulch, and coffee chaff. The onset of morbidity was slightly slower but mortality also reached 100% by the 13th week on peat moss, by the 14th week on pine bark nuggets, and by the 16th week on extra fine bark mulch. Mortality exceeded 80% but did not reach 100% on several dyed wood chip mulches and cedar mulch. Mortality reached approximately 60% on two mixed bark and wood chip products. Termites appeared healthy and mortality remained relatively low on two other color-enhanced wood chip mulches and on the pine wood controls for the duration of the 16 weeks. The most recommendable soil covers are non-organic materials such as sand, pea gravel, decorative stone and rubber mulch. Among organic materials the most recommendable ground cover mulches are cocoa shell mulch, pine bark nuggets, and other pure bark products. Recommendable organic soil amending materials are sphagnum peat moss and coffee bean chaff. Wood chip mulches, including color-enhance wood chip mulches, and any bark mulch that includes a mixture of wood chips are not recommended.

Key Words: Isoptera, Rhinotermitidae, *Reticulitermes*, termite feeding preferences, termite diet, termite nutrition, termite starvation, termite cannibalism, termite resistant mulch.

Introduction: Yard Wood Management (YWM) is a critical component of area-wide termite management projects, including the City of Guelph's termite management program (Myles, 2008). This involves the elimination or replacement of all types of yard wood in soil contact which could serve as feeding resources or nesting habitat for subterranean termites. Wood chip mulch is a common example of yard wood which is highly conducive to the growth and expansion of termite populations. Therefore it is desirable to identify alternative mulch, ground cover, and organic soil amendment products on which termites cannot derive sufficient nutriment or adequate nutrition for prolonged survival.

Materials and Methods: Termite survival on various mulches was assessed using the eastern subterranean termite, *Reticulitermes flavipes* Kollar (Isoptera: Rhinotermitidae)

according to a standard test protocol for termite resistance (ASTM, 1999) with minor modifications. The 15 tested materials, product names, manufacturers, and descriptive notes are listed in Table 1. In addition to the test materials, a concurrent control was run using white pine (*Pinus strobus*) wood blocks measuring 2.5 X 2.5 X 0.5 cm.

There were five replicates per treatment and control. Each replicate was set up in a Ziploc "Twist 'n Loc" food container (473 ml). Quikrete Premium Play Sand was baked to sterilize and used as the termite foraging matrix. A 4 oz. Solo cup was filled with dry sand and levelled with a metal edged ruler to measure an equal volume of sand into each container (213 grams). Twenty-eight (28) ml of tap water was added to moisten the sand, which was determined to be 5% less than the water saturation capacity of the sand. A two gram (dry weight) sample of each test material was placed on top of the sand. Finally, one gram of foraging termites (mixed castes of workers, soldiers and nymphs) was added to each replicate, which was determined to be approximately equivalent to 313 termites based on the average of three counted subsamples of 100 termites. Termites were taken from laboratory stock colonies that were healthy at the start of the experiment. The screw cap container lids were screwed shut and then unscrewed about 1/8 of a turn to allow slight air circulation.

All replicates were kept on a lab bench top at room temperature (ca. 23°C) for the duration of the test. Each replicate was observed weekly by removal of the lid and noting the termite's condition as follows: 1) "H": *healthy*, tunnelling below surface level with no or few termite on top of sand, 2) "T": ten or more termite on *top* of sand, 3) "M": many termites on top and some *moribund* or dead termites noted, or 4) "X": all *dead*. The experiment was allowed to run for 16 weeks at which time the remaining replicates with live termites were dismantled, the sand spread on a tray, and the number of surviving termites in each replicate counted. Visual evidence of feeding on the test materials and plastering of tunnels with test material was also noted (Figure 1 & Table 1).

The percent mortality data were transformed using the angular transformation (arcsine of square root) to normalize percentage data (Table A16, Snedecor and Cochran, 1967). Bartlett's Test for homogeneity of data indicated that variance was not homogeneous when the seven treatments with 100% mortality were included. Excluding these, a one-way completely randomized ANOVA was run on mean mortality using CoStat Software (Version 6.0). Student-Newman-Keuls test was used at the 0.05 significance level to identify non-significant ranges (Table 1).

Results: Tested materials are listed in Figure 1 and Table 1 according to the order in which 100% mortality was reached or by percent mortality when less than 100%. Mortality from highest to lowest was as follows: AllTreat Coco Bean Mulch > Intl. Mulch Rubberific Redwood Mulch > Planet Bean coffee bean chaff > AllTreat Decorative Stone > Nirom Peat Moss > AllTreat Pine Bark Nuggets > AllTreat 100% Natural Bark Mulch > AllTreat Black Beauty > AllTreat Red Devil > Hillview Cedar Mulch > AllTreat Cypress Gold > AllTreat Rustic Bark Mulch > AllTreat Canada Red Bark Mulch > Scotts Classic Black > pine wood control blocks > Scotts Sierra Red.

As shown in Figure 1 and Table 1, the results may be divided into four categories. In the first category, mortality reached 100% by the 11-16th weeks. This category included two non-organic products, decorative stone and rubber mulch, on which there was no visible feeding on the materials and termites in these tests did not plaster their galleries. This shows that, as expected, when the termites had no cellulosic food they eventually starved. Even so, the starvation was surprisingly gradual, with termites starting to mill about on the surface at 3-7 weeks, morbidity setting in from 8-11 weeks, and complete mortality requiring 12 weeks.

Evidently, cannibalism provides a short term alternative feeding strategy for these social insects, and a few semi-cannibalized, (and still living!) individuals were observed in most of these tests. Although a few cannibalized termites were observed, it was apparent that termites are unable to make a successful long term shift to cannibalism as a means of group survival in the absence of their normal diet of lignocellulosic food.

It is of further interest to note that termites starved at approximately the same time on three organic materials: cocoa shell mulch, coffee bean chaff, and sphagnum peat moss, as they did under the strict starvation conditions of the non-organic materials. This occurred even though the termite galleries were plastered with dark material indicating that they had ingested these materials and yet failed to derive any nutritional benefit to prolong their lives. Mortality was delayed on the pine bark nuggets and the pure bark mulch suggesting that the ingested material, in these cases, probably included minute quantities of digestable cellulose, yet not a sufficient amount to sustain life.

In the second category, morbidity set in by 13-14 week and mortality exceeded 80% by the 16th week. This category include three dyed wood chip products as well as cedar mulch. Although it appears that termites may have eventually died out on these products, they were able to derived sufficient nutrition to significantly prolong their survival compared to category 1 materials.

In the third category mortality reached about 60%. This category included two AllTreat products, Rustic Bark and Canada Red, both including a mixture of bark and wood chips. In both tests, three of the five replicates remained healthy to the end of the test. In the final category all replicates remained healthy through the duration of the 16 week test. This category included two Scotts brand color-enhanced wood chip mulches, in which final mortality was not significantly different from the pine wood control.

***Discussion*:** Prolonged survival means that the termites were able to feed on and derive sustenance from the mulch material. Shorter term survival means that the termites either starved, derived inadequate nutrition, or suffered toxic effects on the material.

It was interesting and unexpected that termites feeding on 13 of the 15 tested materials had significantly higher mortality than on the pine wood control. There seem to be two possible interpretations for this, either the mulches provided inadequate nutrition for prolonged survival and/or the mulches were somewhat toxic. The two non-organic materials, decorative stone and rubber mulch, demonstrated a nearly identical pattern of termite decline, which may reasonably be interpreted as the starvation sequence. Thus

the starvation sequence under the test conditions appeared to involve the onset of surfacing behaviour at 3-5 weeks, morbidity appearing in the 8th week and complete mortality in all replicates by the 12th week. None of the test materials exhibited a more rapid decline than the slow starvation sequence and therefore we may infer that none of materials were toxic, or at least not strongly so. Since the time course of termite decline was nearly identical to the starvation sequence for cocoa mulch and coffee bean, it seems reasonable again to interpret this as starvation. This interpretation is also consistent with the fact that these materials are derived from non-vascular plant matter and therefore low in the cellulosic material which characterizes vascular plant tissue, and cellulose is known to be the energy source for termite nutrition (Slaytor, 2000).

A slightly slower, but eventually fatal decline of the termites on peat moss, pine bark nuggets, and fine bark also seems consistent with the interpretation of inadequate nutrition. These materials are also derived from non-cellulosic and non-vascular forms of plant biomass, high in lignin and, in the case of bark, secondary plant compounds.

Termites exhibited even slower mortality on several other wood mulch products, yet this mortality was still significantly higher than in the pine control (e.g., AllTreat Black Beauty, Red Devil, Cypress Gold, Rustic Bark, and Canada Red and Hillview Cedar Mulch). It is difficult to interpret the enhanced mortality in these cases as being due to an inadequacy of digestable cellulose, since these products are substantially composed of wood chips (xylem tissue high in cellulose). Furthermore, since most of these materials are dyed or "color-enhanced", the possibility seems to exist that the dyeing material may lend a slight degree of toxicity to the products. But such hypothetical toxic effects, in any case, are slight and the onset is very slow. One can assume that this effect would be even less under field conditions where termites would be feeding on many wood sources. Therefore what little suppressive effect might exist due to coloring agents might be so diluted under field conditions as to have minimal effect.

A practical consideration must also enter the decision as to which products to recommend as suitable in a termite management program. Some of the color-enhanced products induced no significant depression of termite survival (i.e., Scotts Classic Black and Sierra Red) while others slightly enhanced mortality. Since it would be impossible to distinguish in the field those that enhanced mortality from those that do not, it would therefore be impossible to enforce which should or should not be used. For this reason, some of the materials which did induce higher mortality than in the control, still can not be recommended at this time for use in a municipal control program. Further research is needed to clarify the longer term impact of termite feeding on such mulches under choice-feeding conditions.

From a termite prevention standpoint, the most recommendable materials would be non-organic ground covers such as sand, pea gravel, decorative stone and rubber mulch. Decorative gravel, crushed stone, and stone products come in a wide array of particle sizes, colors and textures of both natural and crushed stone. Such materials allow precipitation to move through to the soil, help to prevent erosion, are long lasting, and inhibit weed growth. Non-organic materials are ideal for garden paths and drives and help to prevent the tracking of mud. Although non-organic materials hold little moisture

themselves, by shading the soil and blocking air movement, they do help to retain soil moisture.

Among the organic materials are included those which tend to be used as ground covers and those that are used mainly as organic soil amendments. Cocoa shell mulch, pine bark nuggets, and pure bark mulches are the only organic materials, among the tested materials, that can be recommended for top mulching in termite infested areas. Sphagnum peat moss and roasted coffee bean chaff are recommended as organic soil amending materials.

Cedar mulch, though believed by some to be termite resistant, can not be recommended. Also not recommended are many products which have "bark" in the product name, because many such products actually contain substantial quantities of wood chips in addition to the bark. Therefore, only those bark products that are 100% bark, are likely to be termite resistant. See Table 2 for a list of approved and non-approved top mulches and soil amendments for the City of Guelph's termite control program.

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Figure 1. Termite Survival on Various Mulches

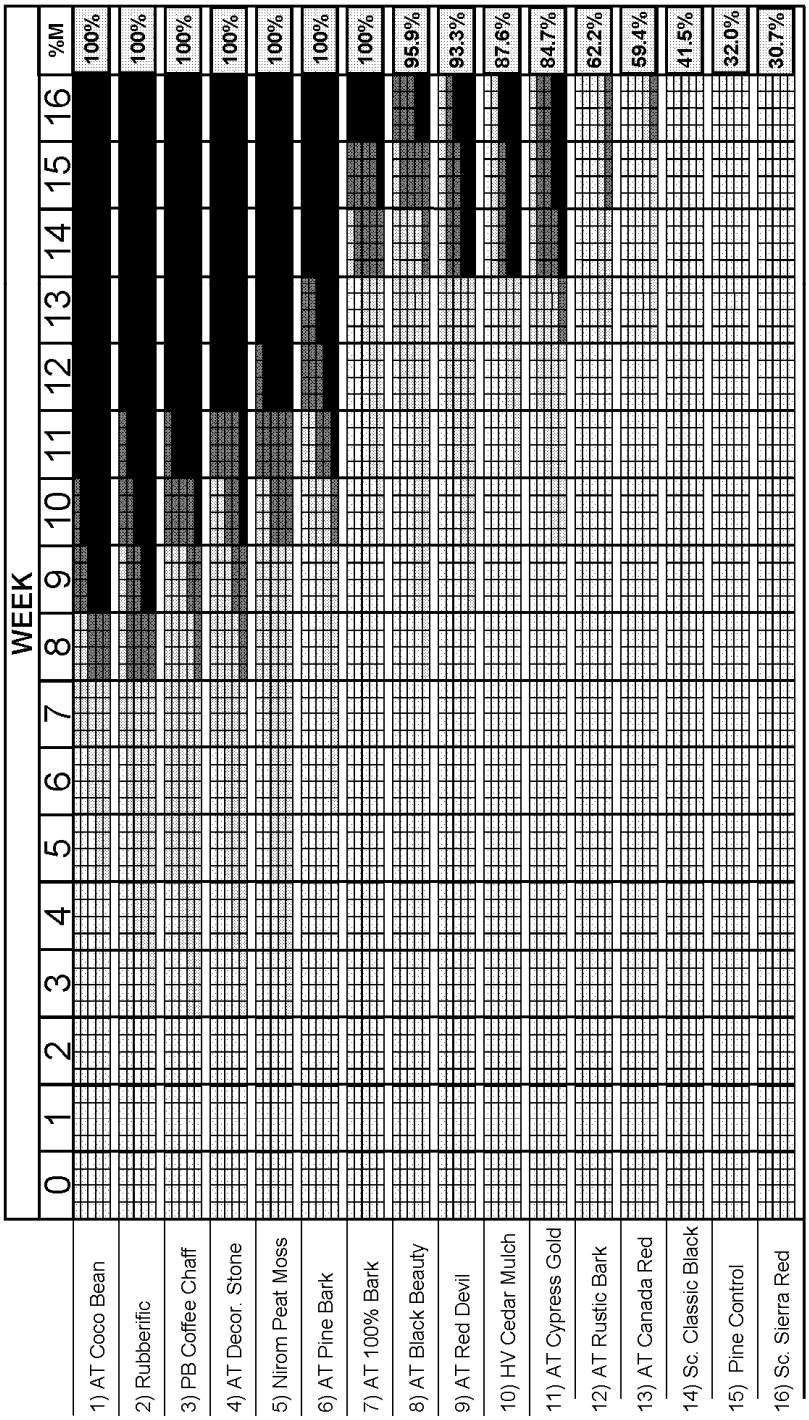

Table 1. Mulch Test Materials and Observations

	Product Name (Description)	Manufacturer[1]	Visible feeding	Plastering tunnels	1st T[2] (wk)	1st M[2] (wk)	1st X[2] (wk)	final X[2] (wk)	% Mort.	Sig.
1	Cocoa Shell Mulch	AllTreat	?	Y	5	8	9	11	100%	-
2	Rubberific Mulch (from recycled tires)	Intl. Mulch	N	N	3	8	9	12	100%	-
3	coffee bean chaff	Planet Bean	?	Y	3	8	10	12	100%	-
4	Decorative Landscape Stone	AllTreat	N	N	3	8	10	12	100%	-
5	sphagnum peat moss	Nirom	?	Y	3	10	12	13	100%	-
6	Pine Bark Nuggets	AllTreat	Y	Y	6	10	11	14	100%	-
7	4 Seasons 100% Bark Mulch (extra fine)	AllTreat	Y	Y	10	14	15	16	100%	-
8	Black Beauty Landscape Mulch	AllTreat	Y	Y	8	14	16		95.9%	a
9	Red Devil Landscape Mulch	AllTreat	Y	Y	9	14	14		93.3%	a
10	Cedar Mulch	Hillview	Y	Y	11	14	14		87.6%	a
11	Cypress Gold Landscape Mulch	AllTreat	Y	Y	10	13	14		84.7%	a
12	Rustic Bark Mulch	AllTreat	Y	Y	13	15			62.2%	b
13	Canada Red Bark Mulch	AllTreat	Y	Y	13	16			59.4%	b
14	Classic Black Color Enhanced Mulch	Scotts	Y	Y					41.5%	bc
15	pine wood control	--	Y	Y					32.0%	c
16	Sierra Red Color Enhanced Mulch	Scotts	Y	Y					30.7%	c

[1]Manufacturer's addresses or contact information:
AllTreat Farms Inc., 7963 Wellington Road 109, Arthur, ON N0G 1A1
Hillview (Nu-Gro Inc.), 10 Craig St., Brantford ON N3R 7J1
IMC (Intl. Mulch Corp.), One Mulch Lane, St. Louis, MO 63044
Nirom Peat Moss Inc., Riviere du Loup, Quebec GR5 3Z1
Planet Bean, 259 Grange Road, Unit 2, Guelph, ON N1E 6R5
Scotts Canada, www.scottscanada.com 1-800-543-TURF

[2] T= on top, M = moribund, X = all dead

Table 2. Approved Top Mulch and Soil Amendment Materials

	Manufacturer[1]	Product Name	Outcome[2]	Use[3]
1	AllTreat	4 Seasons 100% Bark Mulch	Approved	TM
2	AllTreat	Black Beauty Landscape Mulch	Not	
3	AllTreat	Canada Red Bark Mulch	Not	
4	AllTreat	Cocoa Shell Mulch	Approved	TM
5	AllTreat	Cypress Gold Landscape Mulch	Not	
6	AllTreat	Decorative Landscape Stone	Approved	TM
7	AllTreat	Pine Bark Nuggets	Approved	TM
8	AllTreat	Red Devil Landscape Mulch	Not	
9	AllTreat	Rustic Bark Mulch	Not	
10	Hillview	Cedar Mulch	Not	
11	Intl. Mulch	Rubberific Mulch (Redwood)	Approved	TM
12	Nirom	peat moss	Approved	SA
13	Planet Bean	coffee bean husk	Approved	SA
14	Scotts	Classic Black Color Enhanced Mulch	Not	
15	Scotts	Sierra Red Color Enhanced Mulch	Not	

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Scotts Canada, www.scottscanada.com 1-800-543-TURF

[2] See mulch test results at: http://guelph.ca > quick links > termites

[3] TM = Top Mulch; SA = Soil Amendment